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Appn. Title: Multipass Geometry and Constructions for Diode-Pumped Solid-State Lasers and Fiber Lasers, and for Optical Amplifier and Detector

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Information Disclosure Statement

COMMISSIONER OF PATENTS AND TRADEMARKS
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Sir:

Attached is a completed Form PTO-1449 and copies of the pertinent parts of the references cited thereon. Following are comments on these references pursuant to Rule 98. On the other hand, applicant also presents the interpretation for claims and their patentability at the same time.

Claim 1, First Independent Claim

In the present claimed method a novel slab laser arrangement is presented, in which a zig-zag laser slab is collaborated with a one-dimensional prism beam-expanding cavity. This combination is capable of employing a laser slab with a large aspect ratio of its height to its thickness, and effectively solving thermal distortion problems, obtaining TEM_{00}-mode operation and all-out energy extraction from a laser slab. On the other hand, in its following dependent claims, several superior multipass pumping approaches for a zig-zag laser slab are disclosed and defined. These novel pump configurations are able to provide intense uniform pumping and excellent thermal management.

Besides, as indicated in its dependent claims, the claimed arrangement is able to achieve high-performances of intracavity harmonic generations and true cw-mode operations over wide spectral ranges, from red, blue to ultraviolet. Moreover, when some slab-shaped nonlinear crystals and/or Q-switch are inserted to the expanded mode portion of such a cavity, the extra-high power/energy operations with SHG or high order harmonic generations can be obtained. Meanwhile, a white DPSS laser or multi-wavelength DPSS laser also can be produced with the use of this configuration.

A properly designed slab laser with zig-zag laser path is well known for reducing undesired thermo-optic effects. However, the related critical design issues and engineering problems are extremely tough in the art. After two decades of development work, the laser community has still not accepted the slab laser. The reasons for that are a number of practical engineering problems which have prevented so far the realization of the potential advantages of the zig-zag slab laser over the rod geometry.

One of a major issue is low efficiency due to the awkward rectangular geometry of a laser slab. It is difficult for a regular laser cavity to realize all-out laser energy extraction from a laser slab, particularly whose width is increased beyond a few millimeters. However, it is necessary for a laser slab with a large aspect ratio of its height to its thickness in order to solve thermal distortion problems effectively. In the prior art, folded resonator configurations usually are applied that pass a smaller beam through the slab at several positions so as to extract power from a large fraction of the slab volume.

In conclusion, the prior art neither teaches nor suggests the claimed method in claim 1.

1. In U.S. Pat. No. 5,103,457 and the corresponding published paper (Optics Lett 16 (1991) 5, 318), Wallace et al. show a end-pumping scheme with a thin layer pump region, in which the prisms is used as the mode-shaping means to re-shape the TEM_{00} mode to a cross-sectionally elliptical mode so that to match the thin elliptical laser diode beams. The pump light from a linear array laser-diode bar is imaged into an elliptical laser mode and focused by an aspheric condenser lens in two dimension. However, this parent patent neither teaches nor suggests a zig-zag laser slab to be collaborated with a one-dimensional prism beam-expanding cavity.

2. A.D. Hays and R. Burnham, "High duty-cycle diode-pumped Nd:YLF slab laser", Advanced Solid-State Lasers Conference, February 1-3, 1993, New Orleans, LA. In this paper, a pair of one-dimensional prism beam expander is employed for a side-pumped regular laser slab so as to obtain mode-matched pumping. However, this parent patent neither teaches nor suggests a zig-zag laser slab to be collaborated with a one-dimensional prism beam-expanding cavity.

Claim 9, Second Independent Claim

In the second independent claim, i.e., claim 9, there mainly are ten different multipass formations for configuring various multipass pumping heads. These ten different multipass formations can be used separately or collectively between them at the same time in order of more effective. In other words, two different formations among them could work together.

These multipass formations are used to confine the pumping light. Therefore, the pumping light, once entering, undergoes multiple reflections and multiple travels through or within laser medium to be absorbed.

The pump technology is the core technology for DPSS lasers that has been evolving and undergoing over five generations. The present invention has successfully developed the newest generation pump technology for rod lasers, slab lasers and disk lasers. It will be going to open a brand-new chapter for various multipass-pumping configurations, such as multipass face pumping for laser slabs with face cooling, multipass edge pumping for disk lasers, and corner reflector multipass pumping for laser rods. They are simple, better, low cost, large tolerance and highly efficiency and effective.

[First Multipass Formation] defined by the step D (1) of claim 9

"a first multipass formation with the use of optical total-internal-reflection configuration, which additionally comprises the steps of making said multipass pump head as a TIR-guide pump head by mean of an optical duct means, leading to confining said pumping light within said TIR-guide pump head mainly via total-internal-reflection during the entire pumping process; wherein said pumping light, once entering said pump head and said optical duct means, will undergo zig-zag optical paths, multiple reflections and multiple travels through or within said laser medium means until it is absorbed, and ii) the escape loss possibility of unabsorbed said pumping light is at least less than 40% within one round trip pumping path, or at least less than 40% during the entire pumping process; whereby i) significantly reducing multiple reflection losses caused by the zig-zag optical paths, ii) confining said pumping light within said pump head to achieve effective and efficient uniform pumping; and iii) with the use of said optical duct means, eliminating hot spot issue caused by directly diode bar pumping for DPSS lasers;"

3. Recently in several U.S. patents and published papers, the scientists at TRW and Prof. Byer et al. at Stanford University presented their newest development in the edge-pumped zig-zag DPSS slab laser. It is characterized by i) edge-pumping approach, and ii) one or two of the major surfaces of the laser slab is directly in contact with a cooler or heat sink. In fact, these two characters have already been described in commonly owned patent 5,515,394. The only different is that, the relevant approach in U.S. patent 5,515,394, i.e., a parent patent of above patent application, is for general or regular laser slabs rather than a specific zig-zag laser slab. However, in U.S. patent 6,373,868, i.e., the another parent patent of above patent application, a zig-zag laser slab, i.e., a laser slab with an optical propagation along a zig-zag path, was given on the date earlier than the filling date or publish date of these patents or papers.

These patents and published papers are list by the following:

3-1 U.S. Pat. No. 5,949,805 "Passive conductively cooled laser crystal medium," David W. Mordaunt; Randall J. St. Pierre; George M. Harpole; James M. Zamel

3-2 U.S. Pat. No. 6,134,258 "Transverse-pumped Slab laser/amplifier," Tulloch; William; Rutherford; Todd; Byer; Robert L.

3-3 T. S. Rutherford, W. M. Tulloch, S. Sinha, and R. L. Byer, "Yb:YAG and Nd:YAG edge-pumped slab lasers" Opt. Lett. 26 (July 2001) 13, 986

3-4 T. S. Rutherford, W. M. Tulloch, E. K. Gustafson, and R. L. Byer, "Edge-pumped quasi-three-level slab lasers: design and power scaling", IEEE J. Quantum Electron. 36 (Feb., 2000)2, 205

3-5 T. S. Rutherford, W. M. Tulloch, E. K. Gustafson, and R. L. Byer, "Proposed design for a 100kW solid-state laser", Solid State and Diode Laser Technology Review 2000, 5-8 June 2000, Albuquerque, New Mexico

[Important Note] First, the above patent application has both of patent priority and superiority over those cited patents. Second, the claimed invention or subject matter in those cited patents has been already claimed in the second independent claim in the parent patent of above patent application, i.e., U.S. patent 5,515,394. **Therefore, applicant is really not clear that whether these patents should belong to the prior art or not.**

Furthermore, all these patents and published papers list above neither teach nor suggest using the claimed method, by means of an optical duct means, to make a multipass TIR-guide pump head for a zig-zag laser slab. The TIR-guide pump head is advanced in intense uniform pumping and excellent thermal management, much better than Byer's or TRW's approach.

In fact, it is difficult to obtain uniform pumping with the use of the Byer's approach except in the case of so-called transparency pumping for the quasi-three-level system. On the other hand, the TRW's approach has a complex coupling optics and is not able to deal with thin laser slabs.

The feature of the claimed method is distinguished by that, the pumping light is confined within the TIR-guide pump head mainly via total-internal-reflection during the entire pumping process. The pumping light, once entering the pump head and the optical duct means, will undergo zig-zag optical paths, multiple reflections and multiple travels through or within a zig-zag laser slab until it is absorbed.

Meanwhile, the most important revolutionary approach is shown in Figs. 15 I-J, Figs. 15 K-M, Figs. 15 N-O, Figs. 15 P-Q and Figs. 15 R-S, where the pumping face also is the cooling face. That is, multipass face pumping with face conductive cooling for laser slabs. In contrast to traditional arrangements in the art the pumping face is distinct from the cooling face. On the other hand, the cost for these pump arrangements are much less than the fiber-coupled pump approaches, which are mainly used by Byer and TRW.

4. In U.S. Pat. No.5,841,805 "Three-level laser system ",Hagop Injeyan and Jacqueline G. Berg apply the face pumping to a zig-zag laser slab.

5. In several U.S. patents and published papers, TRW scientists disclose an end pumping approach to pump the end internal face for a zig-zag laser slab and to pump the end outer face with a zig-zag pump path for a laser amplifier. However, this laser amplifier dose not have a zig-zag laser path.

These patents and published papers are list by the following:

5-1 U.S. Pat. No.6,268,956 "End pumped zig-zag slab laser gain medium", Hagop Injeyan, Carolyn S. Hoefer and Stephen P. Palese

5-2 U.S. Pat. 6,256,142 "End pumped zig-zag slab laser gain medium", Hagop Injeyan, Carolyn S. Hoefer and Stephen P. Palese

5-3 U.S. Pat. 6,094,297 "End pumped zig-zag slab laser gain medium", Hagop Injeyan, Carolyn S. Hoefer and Stephen P. Palese

5-4 Gregory D. Goodno, Stephen Palese, Joseph Harkenrider, and Hagop Injeyan, "Yb:YAG power oscillator with high brightness and linear polarization", Opt. Lett. 26 (1 November 2001) 21, 1672

6. In U.S. Pat. No. 4,949,346 "Conductively cooled, diode-pumped solid-state slab laser", Jerry W. Kuper and William R. Rapoport apply the face pumping to a zig-zag laser slab which is sandwiched by two transparent, thermally conductive heat sinks.

7. The pump approach shown in Figs. 9A-C in above patent application is similar to the pump arrangement by means of the lens duct as reported by R. J. Beach et al. in their U.S. Pat. 5,307,430, or in their paper Opt. Lett. **18** (1993)1326, and Gilles Feugnet et al., "High-efficiency TEM_{00} Nd:YVO4 laser longitudinally pumped by a high-power array", Opt. Lett. **20** (1995) 157. However, in all of their approaches, they do not try to use optical duct to realize zig-zag pump paths so as to obtain multipass pumping.

8. U.S. Pat. 6,222,872 "Delivering pump light to a laser gain element while maintaining access to the laser beam" to Raymond J. Beach, Eric C. Honea and Stephen A. Payne. In this patent a lens duct is used for pump delivery. On the other hand, the laser beam is accessed through an additional component called the intermediate beam extractor (IBE) which is very similar to the lens duct and can be implemented as part of the gain element, part of the lens duct or a separate component entirely. However, these Livermore scientists and researchers have not considered using their lens duct and IBE to realize zig-zag pump paths and to obtain multipass pumping for a zig-zag laser slab.

9. R. J. Shine, Jr., A. J. Alfrey, and R. L. Byer, "40-W cw, TEM_{00}-mode, diode-laser-pumped, Nd:YAG miniature-slab laser", Opt. Lett. 20 (March 1, 1995) 5, 459. In this paper, Prof. Byer et al. provide a water cooled, zig-zag slab laser pump head which looks like similar to that shown in Figs. 16A-P in above patent application. However, they only simply employ fiber-coupled pump approach rather than using multipass, zig-zag pump paths via total-internal-reflection within the pump head.

10. In U.S. Pat. 6,055,260 "Laser pump cavity apparatus with integral concentrator and method", or U.S. Pat. 5,974,061, or U.S. Pat. 6,014,391, Robert W. Byren et al. disclose a multipass pump cavity for laser slabs. The pump cavity mainly consists of a pair of opposing cladding which have two cylindrical focusing surfaces, preferably with hyperbolic or quasi-hyperbolic shape. A laser slab is sandwiched between the pair of opposing cladding. This pump configuration provides the multipass face pumping with face conductive cooling for laser slabs. However, its structure is complex which will result in difficulty for manufacturing and low cost. It also will cause a big trouble in dealing with thin laser slabs. In addition, a same pump cavity is already used for pumping laser rod in Fig. 4 in U.S. Pat. 5,349,600.

11. In Patent Application Publication US 2002/0057725 and U.S. Pat. 6,418,156 "Laser with gain medium configured to provide an integrated optical pump cavity", Eugene R. Peressini invents a multipass pumping approach based on U.S. Pat. 5,974,061, U.S. Pat. 6,014,391, and U.S. Pat. 6,055,260 with the same assignee Raytheon, in which he use an outside coating, or make a laser rod or slab have a tapered shape to confine the pumping light within the lasing medium. The above patent application has both of patent priority and superiority over this patent.

12. In U.S. Pat. 5,553,088 "Laser amplifying system", Uwe Brauch, Adolf Giesen, Andreas Voss and Klaus Wittig invent a primary disk laser structure. However, they never suggest and consider using the claimed method, by means of an optical duct means, to make a multipass TIR-guide disk pump head. The variety of TIR-guide disk pump heads presented in the present invention are able to provide intense uniform pumping within a very small area which is vital for the success of disk laser operations.

13. Luis Zapata, Ray Beach and Steve Payne, "Composite thin-disk laser scaleable to 100 kW average power output and beyond", Solid State and Diode Laser Technology Review 2000, 5-8 June 2000, Albuquerque, New Mexico. In this paper, a pump arrangement is discovered for pumping the disk laser (shown in Fig. 6) with a zig-zag pump path which is similar to the pump approaches shown in Figs. 9A-B, Fig. 23A and Fig. 23B in the above patent application. However, this pump arrangement is not able to provide multipass pumping. Because its pump path is open-ended, resulting in a large escape pump loss. This situation is same as that of the pump approach shown in Figs. 5A-E in commonly owned or parent patent

6,373,868. And furthermore, the filling date of the patent 6,373,868 is much earlier than the publication date of the paper.

14. In U.S. Pat. 5,581,573 to Ryohei Tanuma, a multipass pump approach is reported for flashlamp pumped zig-zag slab lasers.

15. In U.S. Pat.5, 557,628 to Kazuki Kuba et al., a multipass pump approach is reported for flashlamp pumped zig-zag slab lasers, particularly for laser slab mounting, various slab laser cavities and thermal distributions in laser slabs.

16. In U.S. Pat.5, 351,251 to Norman Hodgson, some multipass pump approaches with flashlamp and face-pumped approach with diode bars are reported for zig-zag slab lasers in operation at 1.444-um.

17. Edward F. Stephens and Damian L. Wise, "A ruggedized fiber laser for force protection capabilities", Solid State and Diode Laser Technology Review 2000, 5-8 June 2000, Albuquerque, New Mexico. In this paper, a unique pump approach is reported for fiber laser or fiber amplifier with a zig-zag pump path, which is similar to the pump approaches shown in Fig. 24 A in the above patent application. However, the zig-zag pump path in this pump arrangement do not undergo total-internal-reflection, leading to significant reflection loss. Furthermore, the pump approach shown in Fig. 24 A in the above patent application is evolved from the pump approach shown in Figs. 19A-D, which is exactly same as that shown in Figs. 17A-D in commonly owned or parent patent 6,373,868. And this patent filling date is much earlier than the publication date of the paper.

[Second Multipass Formation] defined by the step D (2) of claim 9
"a second multipass formation with the use of optical graded-index or step-index configuration,"

The claimed invention, the second multipass formation defined by the step D (2) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of optical graded-index or step-index configurations, both i) uniform multipass pumping with a large acceptance cone, and ii) concentration of the pump power towards the central lasing region of the laser material means. This multipass formation is typically presented in Figs. 2C-E.

[Third Multipass Formation] defined by the step D (3) of claim 9

"a third multipass formation with the use of a noncircular-profile reflector means which has a noncircular cross-section with a convex and closed boundary, wherein i) said laser medium means is a laser rod means which has a lasing axis and a transverse plane perpendicular to said lasing axis, said noncircular cross-section is in said transverse plane, and ii) the maximum dimension inside said noncircular cross-section is at least four-times larger than the diameter of said laser rod means,"

18. Various circular-profile reflectors, or small noncircular-profile diffusive reflectors have been widely used for pumping laser rods serving as the so-called integrating diode pump cavity. The relevant patents and published papers are list by the following:

18-1 U.S. Pat. 4,969,155 "Integrating laser diode pumped laser apparatus"

18-2 U.S. Pat. 5,033,058 "Rod laser with optical pumping from a source having a narrow emitting area"

18-3 U.S. Pat. 5,307,365 "Cavity pumped, solid state lasers Standard Cavity pumping"

18-4 U.S. Pat 5,317,585 "Laser reflecting cavity with ASE suppression and heat removal"

18-5 U.S. Pat. 5,349,600 "Solid state laser"

18-6 U.S. Pat. 5,636,239 "Solid state optically pumped laser head"

18-7 U.S. Pat. 5,867,324 "Side-pumped laser with shaped laser beam"

18-8 Y. Hirano, T. Yanagisawa, S. Ueno, and T. Tajime, O. Uchino, T. Nagai, and C. Nagasawa, "All-solid-state high-power conduction-cooled Nd:YLF rod laser", Opt. Lett. 25 (August 15, 2000) 16, 1168

18-9 Tetsuo Kojima and Koji Yasui, "Efficient diode side-pumping configuration of a Nd:YAG rod laser with a diffusive cavity", Appl. Opt. 36 (July 1997) 21, 4981

18-10 Hee-Jong Moon, Jonghoon Yi, Jaemin Han, Byungheon Cha, and Jongmin Lee "Efficient diffusive reflector-type diode side-pumped Nd:YAG rod laser with an optical slope efficiency of 55%", Appl. Opt. 38 (March 20, 1999) 9, 1772

18-11 Keming Du, Jian Zhang, Michael Quade, Yan Liao, Stephan Falter, Markus Baumann, Peter Loosen, and Reinhart Poprawe, "Nd:YAG 30-W·cw laser side pumped by three diode laser bars", Appl. Opt. 37 (April 20, 1998) 12, 2361

18-12 Sungman Lee, Sun Kook Kim, Mijeong Yun, Hyun Su Kim, Byung Heon Cha, and Hee-Jong Moon, "Design and fabrication of a diode-side-pumped Nd:YAG laser with a diffusive optical cavity for 500-W output power", Appl. Opt. 41 (February 20, 2002) 6, 1089

However, the claimed invention, the third multipass formation defined by the step D (3) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of the defined noncircular-profile reflector means, both i) uniform multipass pumping with a large acceptance cone, and ii) concentration of the pump power towards the central lasing region of the laser material means. The key pump

embodiment relative to the third multipass formation in accordance with the present invention is presented in Fig. 12 B and named as the noncircular-profile corner reflector pump head. Please note that its optical to optical efficiency or diode to rod efficiency could be two times larger than that of a regular corner reflector which is disclosed in commonly owned patent 5,548,608.

19. In U.S. Pat. No. 5,619,522 "Laser pump cavity", George Dube devises a novel multipass pumping configuration. However, he neither teaches nor suggests the claimed first multipass formation by means of a TIR-guide pump head, or the claimed fourth multipass formation by means of a double-layer reflector, or the claimed third multipass formation by means of the defined noncircular-profile reflector means.

20. Several patents and published papers have been presented for pumping fiber lasers with the use of similar pump geometry or zig-zag pumping path, including

20-1 U.S. Pat. 6,370,297 "Side pumped optical amplifiers and lasers"

20-2 U.S. Pat. 5,533,163 "Optical fiber structure for efficient use of pump power"

20-3 U.S. Pat. 5,418,880 "High-power optical fiber amplifier or laser device"

[Fourth Multipass Formation] defined by the step D (4) of claim 9

<u>"a fourth multipass formation with the use of a double-layer reflector means,"</u>

The claimed invention, the fourth multipass formation defined by the step D (4) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of a double-layer reflector means, both i) uniform multipass pumping, and ii) concentration of the pump power towards the laser material means. This multipass formation is typically presented in Fig. 18D.

[Fifth Multipass Formation] defined by the step D (5) of claim 9

<u>"a fifth multipass formation with the use of optical spatial filter or the like configuration;"</u>

The claimed invention, the fifth multipass formation defined by the step D (5) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of optical spatial filter or the like configuration, uniform multipass pumping for laser rods or laser slabs.

This multipass formation is typically presented in Figs. 11A-B and Figs. 12A-B. The key pump embodiment relative to the third and fifth multipass formation is presented in Fig. 12 B and named as the Noncircular-Profile Corner Reflector Pump Head.

[Sixth Multipass Formation] defined by the step D (6) of claim 9 is newly added after filling.
<u>"a sixth multipass formation with the use of a reflector means, wherein i) said laser medium means is a laser slab means which has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut, ii) said laser slab means is cooled via said two major surfaces only, iii) said diode bar means comprises at least one linear array laser diode bar or 2-D stacked diode bar, iv) each said pump entrance receives said pumping light from one or several said diode bars without fiber coupling, and v) said pump light enters said reflector means and multiply passes through said laser slab means via said two major surfaces,"</u>

The claimed invention, the sixth multipass formation defined by the step D (6) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of a noncircular-profile reflector means and diode bars without fiber coupling, uniform multipass pumping for laser slabs.
[Note] In order to protect the present invention properly, this multipass formation, the sixth multipass formation, has been newly added without introducing the "new matter". This formation is typically presented in Figs. 3A-B, Figs. 4A-B and Figs. 4C-D in above patent application.

[Seventh Multipass Formation] defined by the step D (7) of claim 9 is newly added after filling.
<u>"a seventh multipass formation with the use of a noncircular-profile reflector means which has a noncircular cross-section, wherein i) said laser medium means is a laser slab means which has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut, ii) said laser slab means is mounted into a laser slab assembly means without O-rings, preferably via a silicone RTV, in which said laser slab means is sandwiched between two coolant passages via said two major surfaces, iii) the flow direction along said coolant passages is perpendicular to said minor surfaces of said laser slab, and iv) said pump light enters said noncircular-profile reflector means and multiply passes through said laser slab means via said two major surfaces,"</u>

The claimed invention, the seventh multipass formation defined by the step D (7) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of a noncircular-profile reflector means,

uniform multipass pumping for a laser slab pump head specified in Figs. 16A or Figs. 17A in above patent application.

[Note] In order to protect the present invention properly, this multipass formation, the seventh multipass formation, has been newly added without introducing the "new matter". This formation is typically presented in Figs. 16A and Figs. 17A in above patent application.

[Eighth Multipass Formation] defined by the step D (8) of claim 9 is newly added after filling.

The eighth multipass formation is related to multipass face pumping for laser slabs with face conductive cooling. This configuration is neither identically disclosed by nor rendered obvious in view of the prior art.

[Note] In order to protect the present invention properly, this multipass formation, the eighth multipass formation, has been newly added without introducing the "new matter". This formation is typically presented in Figs. 15N-O, 15P-Q and 15R-S in above patent application.

[Ninth Multipass Formation] defined by the step D (9) of claim 9 is newly added after filling.

The ninth multipass formation is related to multipass face pumping for laser slabs with single face conductive cooling. This configuration is neither identically disclosed by nor rendered obvious in view of the prior art.

[Note] In order to protect the present invention properly, this multipass formation, the ninth multipass formation, has been newly added without introducing the "new matter". This formation is typically presented in Figs. 14A-D in above patent application.

[Tenth Multipass Formation] defined by the step D (10) of claim 9 is newly added after filling.

"a tenth multipass formation with the use of a reflector means, wherein i) said laser medium means is an optical fiber means with a rare-earth-doped core, ii) said diode bar means comprises at least one linear array laser diode bar or 2-D stacked diode bar, iii) said pumping light from one or several said diode bars are optically coupled to one said pump entrance, and iv) said pump light enters said reflector means and multiply passes through said optical fiber means;"

The claimed invention, the tenth multipass formation defined by the step D (10) of claim 9, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass formation which provides, by means of a reflector means, multipass pumping for a fiber laser.

[Note] In order to protect the present invention properly, this multipass formation, the tenth multipass formation, has been newly added without introducing the "new matter". This formation is typically presented in Figs. 19A-D in above patent application.

Claim 26, Third Independent Claim

The invention claimed by the third independent claim, i.e., claim 26, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed multipass apparatus which provides, by means of optical TIR-guide disk reflector or the like, a novel and distinguished configuration for pumping thin-disk lasers, or for building an optical amplifier, or for building an optical or spectral detection.

Meanwhile, in regard to disk lasers, the cited references **12** and **13** in this letter have been given above together some explanations.

Claim 30, Fourth Independent Claim

The invention claimed by the fourth independent claim, i.e., claim 30, is neither identically disclosed by nor rendered obvious in view of the prior art. In particular, the prior art neither teaches nor suggests the claimed method which provides, by means of i) intense uniform multipass pumping, and ii) setting a laser gain region with a limited length at the out of phase location in order to minimize spatial hole burning effect, a solid-state laser with high-power operation at a desired minor laser line. Such a laser is capable of producing modest-to-high red or blue coherent light via intracavity SHG.

21. In U.S. Pat. 5,627,849 "Low amplitude noise, intracavity doubled laser", Thomas M. Baer provides an effective approach to eliminate and minimize spatial hole burning effect. And a sable intracavity SHG has been obtained by way of minimizing mode coupling interactions between the longitudinal modes. However, Baer neither teaches nor suggests to use the claimed method to obtain high-power operation at a desired minor laser line for solid-state lasers, leading to red and blue visible lasers with modest-to-high CW output power.

22. In U.S. Pat. No. 6,320,889 "Solid state laser including a single mode gain swept configuration", Neil MacKinnon describe the gain sweeping technique to eliminate and minimize spatial hole in order to obtain single axial mode operations.

23. G. Hollemann, E. Peik, A. Rusch, and H. Walther, "Injection locking of a diode-pumped Nd:YAG laser at 946 nm", Opt. Lett. 20 (September 15, 1995) 18, 1871. In this paper a low power blue laser is reported, in which with the use of a pair of quarter-wave plates the "twisted mode" technology is employed to minimize spatial hole-burning effect.

24. In U.S. Pat No. 4,809,291 "Diode pumped laser and doubling to obtain blue light", L Robert Byer and Tso Y. Fan provide the elementary approach to produce low-power blue laser. It almost is meaningless for producing modest-to-high power CW blue laser.

Very respectfully,

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U.S. PATENT DOCUMENTS

Examiner Initials *	Cite No.[1]	Document Number Number- Kind Code (if known)	Publication Date MM-DD-YY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-5, 103,457	4-7-92	R. W. Wallace, et. al.	
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	5-1	US-6, 268,956	7-31-01	Hagop Injeyan et al.	
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Substitute for form 1449A/PTO				Complete if Known	
				Application Number	10/099,656
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	03/15/2002
				First Named Inventor	Tong Zhang
				Art Unit	GAU 2881
				Examiner Name	Quyen Phan Leung
Sheet	2	of	3	Attorney Docket Number	

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Application Number	10/099,656
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